Introduction: Fractured terrains on Mars offer insights into the planet's geological history. Orbital data reveal that the region chosen as the landing site for the ESA Rosalind Franklin mission [1] show significant amount of fractures in the Noachian terrains [2] and hydrated minerals have been detected over fractured areas [3]. In our previous mapping effort of the Rosalind Franklin mission landing ellipse we found that at least the 40% of the area shows metric-to-decametric fractures, with a major concentration in the southern region near the Coogoon Valles system [4]. We extended our fracture mapping in the surroundings of the Rosalind Franklin rover's landing site to provide a broad context, towards a regional understanding of Oxia Planum.

Methods: We have mapped metric to decametric fractures using high-resolution images (HiRISE, 0.3 m/pixel) [5] as basemap in the QGIS environment. The mapping area was divided into a grid of 4445 by 1 km squares and extends approximately 50 km in all directions beyond the boundaries of the landing site. We then visually inspected the HiRISE images at a scale of 1:5000 for each square in the grid annotating the presence of fractures within the geodatabase.

For each grid square, we documented an attribute indicating whether the fractures were evident, 'not observable' or 'uncertain'. The 'uncertain' classification was assigned to squares where fractures were barely detectable at 1:5000 scale. We then classified the fractured terrains and their associated morphologic features.

Results: The grid-map classification resulted in 3052 squares marked as "not-observable," 259 squares as "uncertain," and 1134 squares as "evident". The grid-map covers an area of ≈7200 km² unveiling the extension of fractured terrains beyond the boundaries of the landing site. The "evident" and "uncertain" grid-based fractures record (orange and green squares in the grid) show how the presence of fractures tends to decrease as one moves away from Coogoon Valles towards the N-NW, preserving the spatial trend characteristic of the fractured terrains at the Rosalind Franklin landing site. We also classified the fractures with some associated morphologic features: Point bar fractured terrains (53 Yellow squares in the grid), fractured Periodic Bedrock Ridges (FRs, 341 Purple squares in the grid), and Fractured Dark Resistant Units (FDRU, 38 Black squares in the grid).

FRs are concentrated in the center-south (Aquitania, Dalmatia and Lugudensis regions, Fig. 1) and they don’t appear without fracturing at this mapping scale. Additionally, in contrast to previous studies, fractures are present within the DRU in the vicinity of other geological units, extending for a minimum of 1 km (in the Dalmatia, Sicilia, and Nisibis region) and up to 3 km (specifically in the Germania region) inside the DRU.

We also categorized a further class of fractures near the outflow of Coogoon Valles (Fig. 1), which are present in a sedimentary deposit that originated along the inner bank of the paleo-river. The fractures observed in the point bar might indicate the presence of reworked material, potentially finer than the adjacent deposits.

Discussion: The map indicates that the fractures tend to decrease as one moves away from Coogoon Valles towards the N-NW, reflecting the spatial trend characteristic of the Rosalind Franklin landing site (Fig. 1). The concentration of fractures near Coogoon Valles is associated with the geological history linked to the hydrological process of the large outflow channel that cut through the region of Oxia Planum in the past. This channel likely played a crucial part in draining water from the highland regions, thereby influencing the formation and contours of the Oxia Planum landscape [6]. The combination of erosional forces and the dynamic nature of water flow might have resulted in the development of fractures, especially in the areas where the outflow was concentrated.

Fractured terrains on the map correspond also to areas where fractured Periodic Bedrock Ridges (PBR) occur [7]. Although PBRs with smooth (not cross-cut by fractures) surfaces have been identified on Oxia [8], the mapped PBRs are fractured and are concentrated in areas close to Coogoon Valles. Possible causes range from tectonic processes and terrain characteristics to local climatic conditions and erosional processes.

The map indicate fractures in the Dark Resistant Units (Adru) unit [9], that is supposed less prone to fracturing than the surrounding units. Fractures extend at least 1 km (Dalmatia, Sicilia, and Nisibis regions) and up to 3 km (especially in the Germania region) within the DRU. Significant differences in strength between the DRU and the bedrock may have caused the fractures. Bedrock may weather and erode faster
than the more resistant DRU, causing differential erosion and fractures at their contact.

Tectonic activity, present or past, may also have created fractures between the two units due to different deformation responses. The interaction between the DRU and the bedrock partially causes fractures within the DRU, particularly since the bedrock is more susceptible to deformation, weathering, or erosion.

In contrast to the extensively fractured bedrock in the northern areas of the channel, fractures are notably absent in the south, except for a limited area of about 15 square kilometers. The mapped fractures are discernible within a point bar, an arcuate sedimentary deposit forming along the inner bank of a common terrestrial meandering channel [10].

The identification of fractured point bars in the south provides valuable geomorphological insights into the history and dynamics of the Oxia Planum river system.

The geological complexity of Oxia is influenced by the historic hydrogeological activity of the Coogoon Valles and fractured terrain constitutes an important percentage of this region. Our study wants to contribute to the understanding of the processes that shaped the region where the ExoMars Rosalind Franklin rover will land in 2030.


**Figure 1:** Map of fractures and associated morphological features at Oxia Planum. The map illustrates the class of fractured terrains into ‘Evident’, ‘Uncertain’, ‘Not-observable’ fractures and Point bar fractured terrains (Yellow squares in the grid), fractured Periodic Bedrock Ridges (FRs, Purple squares in the grid), and Fractured Dark Resistant Units (FDRU, Black squares in the grid).